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F4U UA U24A1 U24B2 U41

(56) Documents Cited:
GB 2227829 A
US 4308994 A
US 3779307 A
DE 019506935 C1
US 3999598 A

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UK CL (Edition V) F4U
INT CL^7 B60H, F01P
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(54) Abstract Title: **Automotive hvac system**

(57) An automotive hvac system comprises a heat exchanger 2 having an air side where fresh and recirculated air are communicated to a cabin by a fan and an engine coolant side where coolant from an engine 1 is circulated through the heat exchanger 2 by a variable speed electrical pump 5 driven independently of the engine speed. During warm up under cold ambient conditions where rapid heating of the interior of a vehicle is required, coolant flow to a radiator 4 is restricted by a thermostat 3 and diverted through a bypass circuit and back to the pump 5 which is operated at maximum speed and enables the engine 1 to be maintained at a lower working speed. A solenoid valve 8 may be provided in the bypass circuit upstream of the thermostat 3 and during warm up is closed to allow a greater flow of coolant though the heat exchanger 2. Valve 8 may be placed downstream of the thermostat 3 and further valves may be placed in the other circuits.

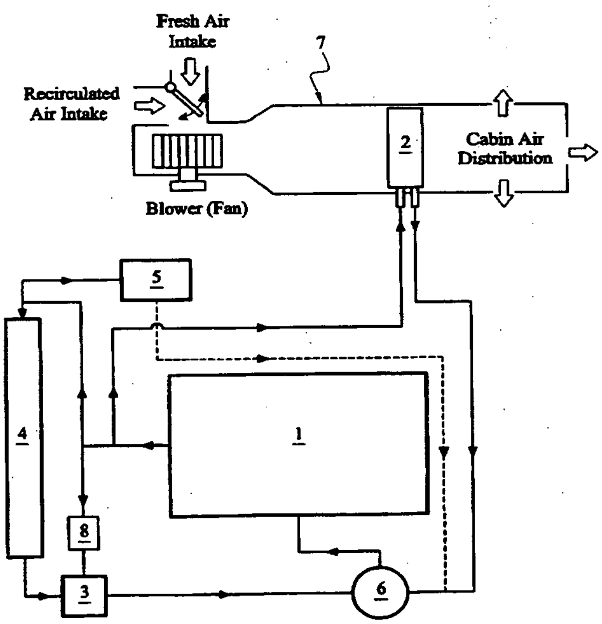

FIG. 4

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GB 2 401 931 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.
Original Printed on Recycled Paper

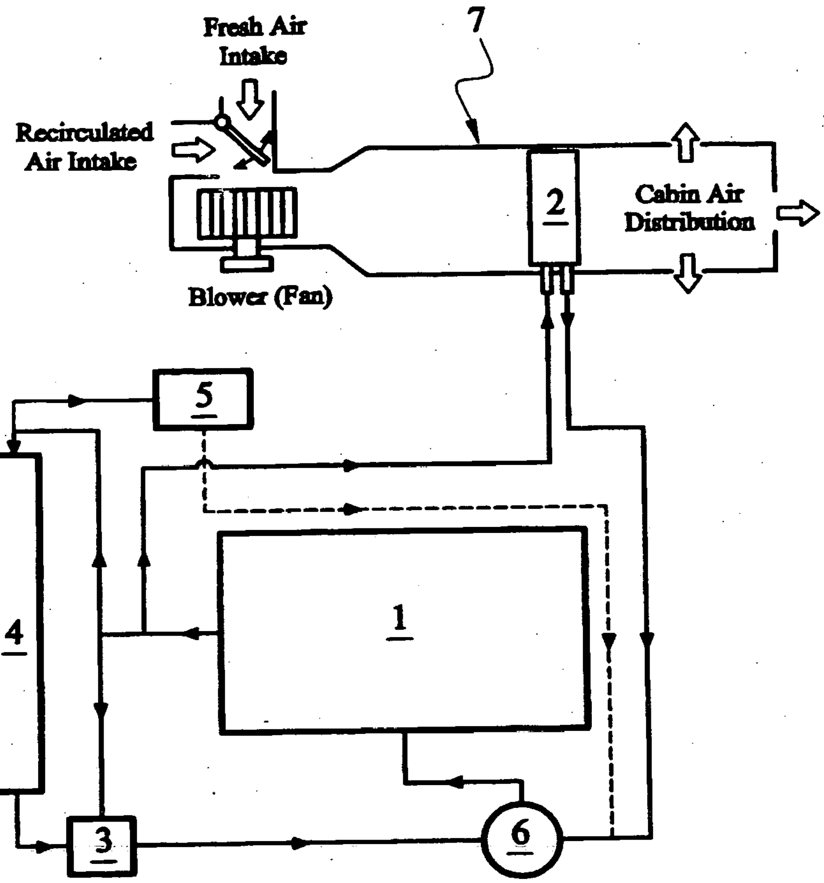
Fresh Air Intake
7
Recirculated Air Intake
2
Cabin Air Distribution
Blower (Fan)
5
4
1
3
6

FIG. 1

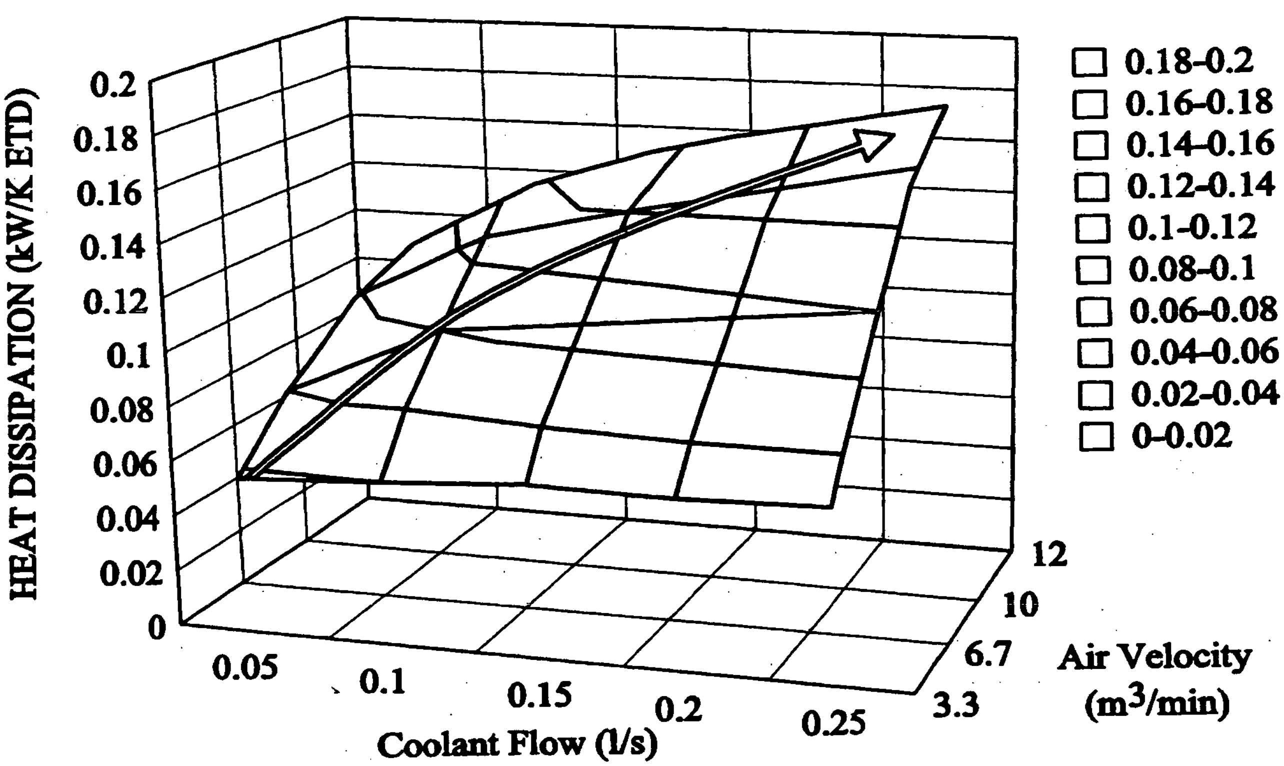
HEAT DISSIPATION (kW/K ETD)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.05
0.1
0.15
0.2
0.25
Coolant Flow (l/s)
12
10
6.7
3.3
Air Velocity (m3/min)
0.18-0.2
0.16-0.18
0.14-0.16
0.12-0.14
0.1-0.12
0.08-0.1
0.06-0.08
0.04-0.06
0.02-0.04
0-0.02

FIG. 2

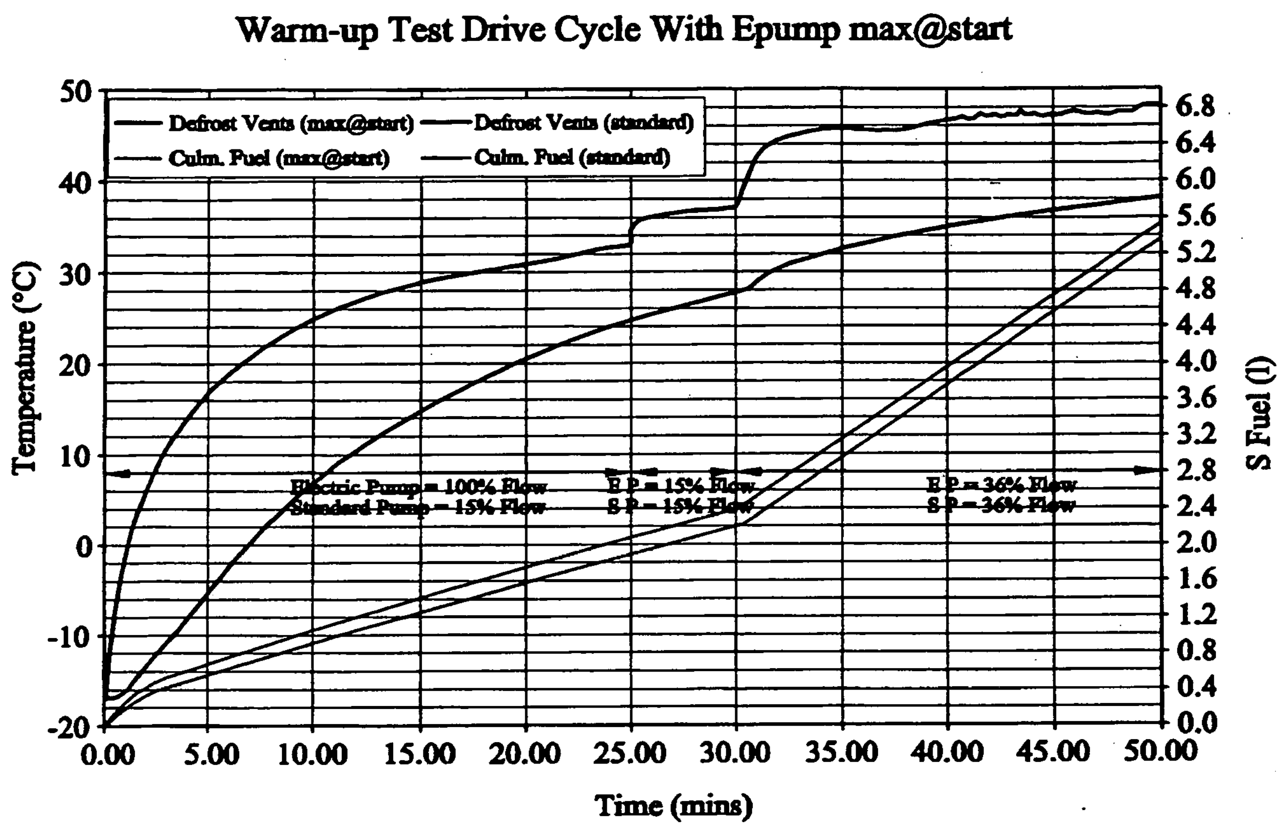
Warm-up Test Drive Cycle With Epump max@start
Defrost Vents (max@start)
Defrost Vents (standard)
Culm. Fuel (max@start)
Culm. Fuel (standard)
Electric Pump = 100% Flow
Standard Pump = 15% Flow
E P = 15% Flow
S P = 15% Flow
E P = 36% Flow
S P = 36% Flow
Temperature (°C)
S Fuel (l)
Time (mins)
50
40
30
20
10
0
-10
-20
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00

FIG. 3(a)

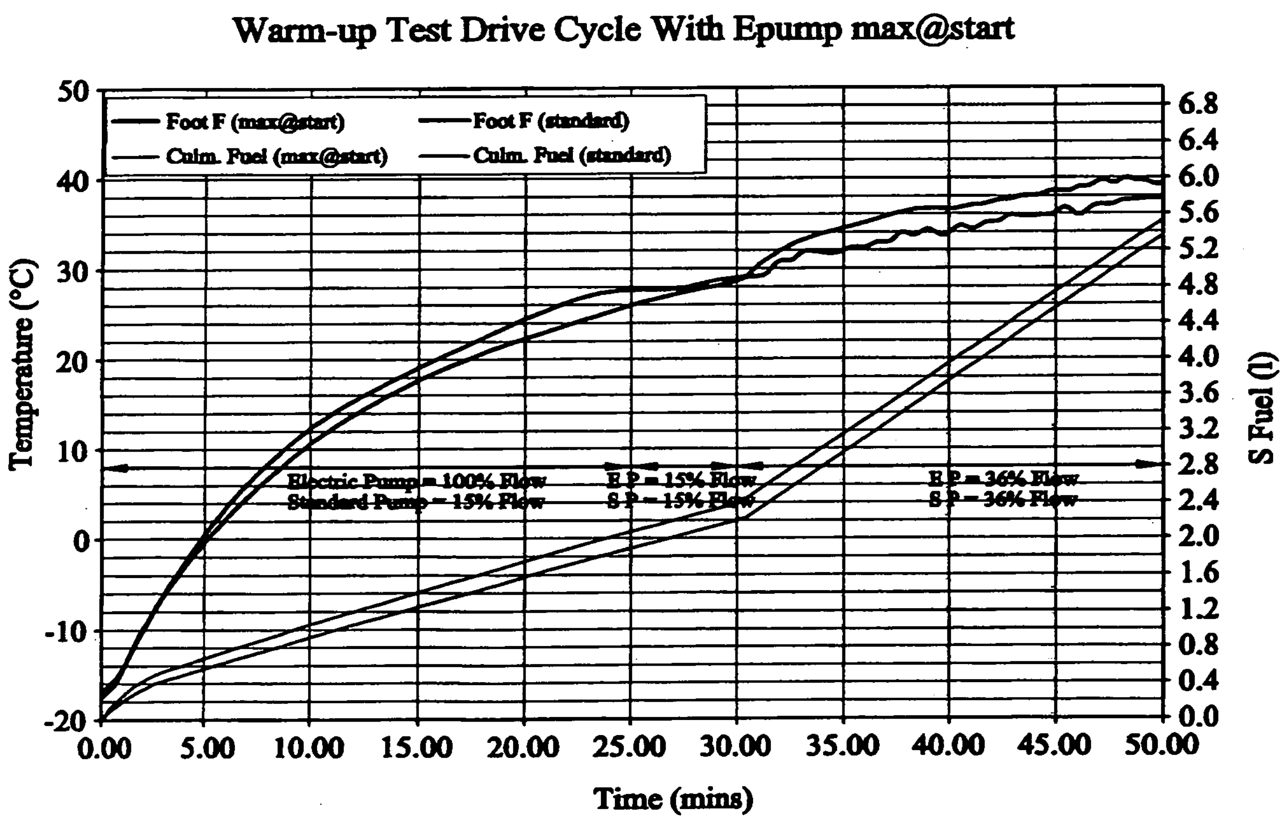
Warm-up Test Drive Cycle With Epump max@start
Foot F (max@start)
Foot F (standard)
Culm. Fuel (max@start)
Culm. Fuel (standard)
Electric Pump = 100% Flow
Standard Pump = 15% Flow
E P = 15% Flow
S P = 15% Flow
E P = 36% Flow
S P = 36% Flow
Temperature (°C)
S Fuel (l)
Time (mins)
50
40
30
20
10
0
-10
-20
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00

FIG. 3(b)

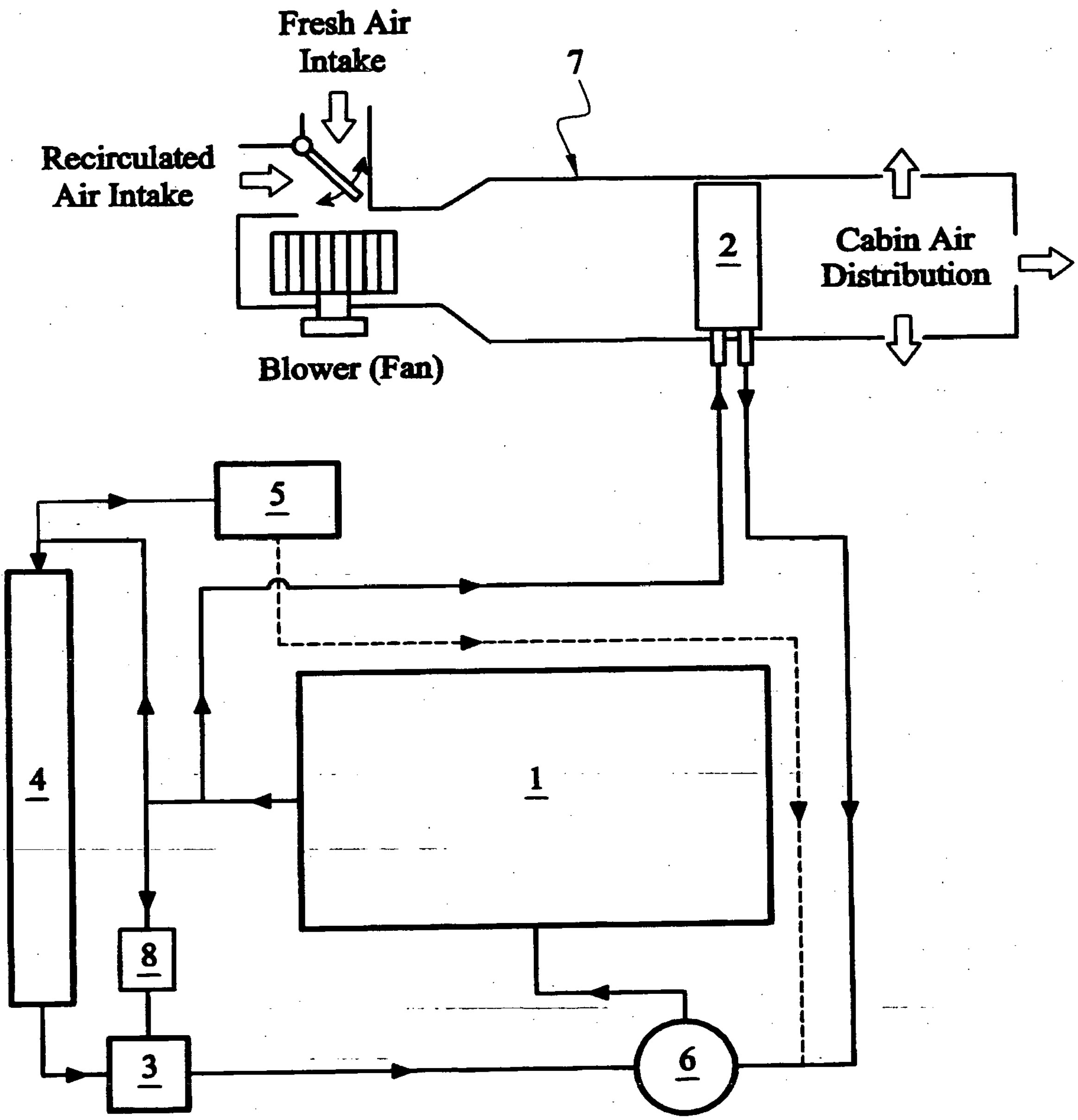
Fresh Air
Intake
7
Recirculated
Air Intake
2
Cabin Air
Distribution
Blower (Fan)
5
4
1
8
3
6

FIG. 4

AUTOMOTIVE HVAC SYSTEM

The present invention relates to an automotive heating, ventilation or air-conditioning (HVAC) system and particularly to such a system including a HVAC heater of heat exchanger type having an air-side and an engine coolant side.

Modern vehicles operate with improved engine efficiency. As a consequence, the amount of heat energy dissipated into the engine coolant circuit has reduced, however, this energy is still relied upon to provide the principal heat source for the interior of the automobile, thereby facilitating in-vehicle comfort and safety. It therefore becomes increasingly important to manage this heat energy intelligently.

The automotive interior is conventionally heated by passing air across a heat exchanger carrying the hot engine coolant, prior to this air being released into cabin. It is therefore acknowledged that the two principle control mechanisms for this heat transfer are respectively, the flow rates of air and coolant, across and within the heat exchanger. Further, in conventional vehicle systems, the flow rate of the coolant is controlled by the engine water pump and the cooling circuit resistances to flow. Valves, such as the conventional thermostat, can be used to alter flow rates within the various coolant circuits in response to some signal. Indeed, modern thermostat developments (such as the pressure response thermostat) can incorporate a pressure relief feature to increase the flow of coolant within the heater core at low coolant pressures.

Such valves redirect the coolant flow, however the maximum flowrate is determined by the vehicle waterpump. Conventional vehicle systems employ a mechanically driven water pump, wherein its speed is directly coupled to the engine rpm. At low engine rpm, the pump delivers a low flowrate, and at high engine rpm, the pump delivers a high flowrate. Modern vehicle systems however, are now incorporating an increasing number of electrically driven auxiliary components. This means that electrically driven water pumps, decoupled from the traditional dependancy of engine rpm, could become more common.

According to a first aspect, the present invention provides an automotive heating ventilation or air conditioning (HVAC) system comprising a HVAC heat exchanger having an air-side and an engine coolant side, the HVAC heat exchanger being arranged to exchange heat between air to be directed into the interior of the vehicle and engine coolant; the system being controlled to modify the engine coolant flow to enhance the HVAC effect of the HVAC heat exchanger.

According to a second aspect, the present invention provides a method of operating a HVAC system including a HVAC heat exchanger having an air-side and an engine coolant side, the HVAC heat exchanger being arranged to exchange heat between air to be directed into the interior of the vehicle and engine coolant; the method comprising modifying the engine coolant flow to enhance the HVAC effect of the HVAC heat exchanger.

Generally, a HVAC system in accordance with the invention includes:

a HVAC heat exchanger having an air-side and an engine coolant side, the HVAC heat exchanger being arranged to exchange heat between air to be directed into the interior of the vehicle and engine coolant;

a monitoring arrangement for monitoring the temperature of the engine coolant and/or the air delivered to the interior of the vehicle;

and one or both of ;

a pump to pump the engine coolant, the pump being controllable to increase the pumping rate of the engine coolant in predetermined demand conditions;

a valve arrangement arranged to modify the route of the engine coolant in the engine coolant circuit in predetermined demand conditions.

It is preferred that wherein the HVAC heat exchanger comprises an air heater and the system is controlled to modify the engine coolant flow to enhance the heating effect of the air heater.

Beneficially, the engine coolant flow is modified dependent upon the temperature of the engine coolant (related to engine operating temperature); and /or the temperature of air directed into the interior of the vehicle; and/or the user demand imposed on the system, typically by the driver or passenger of the vehicle.

Preferably, the modification to the coolant flow can be made independently of change in the vehicle engine speed.

It is preferred that the system is controlled to modify the engine coolant flow rate to enhance the HVAC effect of the HVAC heat exchanger.

In vehicle cold start up conditions where there is a demand for cabin warm up, it is particularly preferred that the system is controlled to increase the engine coolant flow rate to enhance the HVAC effect of the HVAC heat exchanger.

Beneficially, the engine coolant is pumped by a pump and the system is controlled to modify the pumping rate of the pump to modify the engine coolant flow to enhance the HVAC effect of the HVAC heat exchanger. In vehicle cold start up conditions, where there is a demand for the cabin to be heated, it is preferred that the pump speed is increased to increase the the engine coolant flow rate to enhance the HVAC effect of the HVAC heat exchanger.

The pump beneficially comprises an electrical pump. This enables the pump to be operated at variable coolant flow rates independently of the engine running speed.

Additionally or alternatively, the system may be controlled to modify the flow route of the engine coolant to enhance the HVAC effect of the HVAC heat exchanger. The system may accordingly include a valve arrangement (such as a thermostat valve) controlled to modify the engine coolant flow to enhance the HVAC effect of the HVAC heat exchanger. Beneficially, the engine coolant is controlled to ensure that maximum available coolant is diverted through the HVAC heat exchanger during vehicle engine warm-up.

Typically, the system is controlled to be operated such that in cold or cool ambient conditions, when the system is placed under a user demand situation for the interior of the vehicle to be heated, the engine coolant flow to the HVAC heat exchanger is modified to enhance the HVAC effect of the HVAC heat exchanger.

The invention will now be further described in specific embodiments and by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic registration of a HVAC system in accordance with the invention;

Figure 2 is a graphical representation showing performance of an automotive heat exchanger in a system of the invention.

Figures 3(a) and 3(b) are graphical representations showing performance of the system of the invention; and

Figure 4 is a schematic representation of a modified system in accordance with the invention.

Referring to Figure 1, a vehicle includes an internal combustion engine (1), an automotive HVAC and engine coolant system having a heater core (2) having an air-side and an engine coolant side. This heat exchanger (2) facilitates heat transfer to cabin directed air passing across it. Ambient air is directed into the cabin air distribution system via vents and fans and allowed to pass across heater core (2), thereby taking heat from the hot engine cooling fluid flowing within it, and consequently heating the cabin air.

A thermostat valve (3) is generally responsive to engine cooling fluid temperature, and controls flow through the front radiator component (4) and the radiator by-pass circuit.

Radiator heat exchanger (4) facilitates heat transfer to the air passing across it. Ambient air is directed into the engine bay via grills and vents and allowed to pass across this component, thereby taking heat from the hot engine cooling fluid flowing within radiator, and consequently cooling this circuit fluid.

An expansion tank (5) acts as a fluid reservoir for the engine cooling circuit, thereby facilitating fluctuating fluid volume demands within the circuit as a consequence of variation in operating condition.

An electric water pump (6) functions as the pump within the engine cooling circuit, circulating fluid through all components within the circuit under the influence of a created fluid pressure difference. In the considered embodiments, this component is an electrically driven water pump.

A cabin air conditioning and distribution system, includes components including heater core 2, assembled into housings which are shaped to enable vehicle fit and required airflow function into the cabin.

<u>Operation of System During Warm-up</u>

During operation under cold ambient conditions, there is a requirement to maximise vehicle heating from the coolant fluid. Under action of the electric water pump, coolant is forced through the heater core (2). Flow is restricted within the front radiator (4), by action of the thermostat (3) diverting flow through the by-pass and back to the water pump.

Figure 2 describes the heat transfer performance of a typical automotive heater core. In order to maximise heat transfer (and thereby the maximum heating performance from the heater core), both coolant and air flowrates should be maximised. Improved performance is therefore achieved by moving up the curve in the direction indicated by the arrow.

As previously described, conventional, mechanically-driven water pumps are linked to and therefore dependant upon engine speed to increase coolant flow. Thus, during warm-up the air flow would be maximised, but the coolant flow would fluctuate with rpm (engine speed). further, because the driver would typically maintain a safe, low rpm to protect his engine, the water flow would remain low. This would therefore fail to optimise cabin warm-up.

As a result of using an electrically-driven water pump the driver can maintain the engine at the lower, safe working speed (rpm) range whilst the pump will circulate coolant fluid at its maximum flowrate. This therefore maximises the cabin warming performance.

An optimum first-stage strategy for warm-up at cold ambient conditions is preferred in which the electric water (coolant) pump is driven at maximum speed during the initial driving period. Figure 3 demonstrates the performance benefits obtained in cabin heating from such an initial strategy.

In Figure 3(a) and 3(b) the benefits of working the pump at maximum flow during the start are apparent. These curves show the measured air temperatures in the vehicle defrost air vents and front footwells during a standard test drive cycle. The standard cycle is to test in an ambient of -18°C, driving at 50kph for the first 30 minutes, and thereafter at 100kph. With a conventional waterpump driven by rpm, the first stage of the test would represent at 15% flowrate compared to the maximum possible, and the second stage 36%. The benefit of running the waterpump at 100% flow in the first 25 minutes of stage one are evident.

Fuel consumed during testing is also recorded. By running the coolant (water) pump at maximum flow during warm-up, maximum heat is available to the cabin, thereby reducing the heat available to warm up the vehicle powertrain (engine, transmission, etc). A retarded powertrain warm-up would encourage greater frictional losses during the warm-up, thereby increasing the fuel consumption (and emissions). This however is not considered a problem at cold ambients, because passenger comfort takes first priority at such conditions.

There are therefore clear benefits to be gained from such a simple strategy, but these can be extended by sagacious use of valving and flow diversion to fully maximise performance. Figure 4 illustrates a simple extension to Figure 2 to achieve this aim.

Figure 4 incorporates a simple valve (e.g. Solenoid activated open/closed) whose default condition is open. During warm-up, and below a pre-determined maximum operating temperature for the engine, this valve (8) is arranged to close. This effectively blocks the by-pass circuit and ensures a far greater flow rate of coolant through the heater core. (In Figure

4, this valve is placed upstream of the thermostat (3), but could equally be placed downstream.) A further enhancement could likewise be considered by placing valves in ancillary circuits also (e.g. the expansion tank (5) circuit), and such considerations would need to balance that benefits accrued, against the total valve oncosts.

CLAIMS:

1. An automotive heating ventilation or air conditioning (HVAC) system comprising a HVAC heat exchanger having an air-side and an engine coolant side, the HVAC heat exchanger being arranged to exchange heat between air to be directed into the interior of the vehicle and engine coolant; the system being controlled to modify the engine coolant flow to enhance the HVAC effect of the HVAC heat exchanger.

2. A system according to claim 1, wherein the HVAC heat exchanger comprises an air heater and the system is controlled to modify the engine coolant flow to enhance the heating effect of the air heater.

3. A system according to claim 1 or claim 2, wherein the engine coolant flow is modified dependent upon the temperature of the engine coolant.

4. A system according to any preceding claim, wherein the engine coolant flow is modified dependent upon the external atmosphere ambient temperature.

5. A system according to any preceding claim, wherein the coolant flow is modified dependent upon user selected system demand.

6. A system according to any preceding claim, wherein the modification of the coolant flow is substantially independent of the vehicle engine speed.

7. A system according to any preceding claim, wherein the system is controlled to modify the engine coolant flow rate to enhance the HVAC effect of the HVAC heat exchanger.

8. A system according to any preceding claim, wherein the system is controlled to increase the engine coolant flow rate to enhance the HVAC effect of the HVAC heat exchanger.

9. A system according to any preceding claim, wherein the engine coolant is pumped by a pump and the system is controlled to modify the pumping rate of the pump to modify the engine coolant flow to enhance the HVAC effect of the HVAC heat exchanger.

10. A system according to claim 9, wherein the pump speed is increased to increase the the engine coolant flow rate to enhance the HVAC effect of the HVAC heat exchanger.

11. A system according to claim 9 or claim 10, wherein the system is controlled to operate the pump at maximum pump speed to maximise coolant flow rate during an initial warm-up period of the engine.

12. A system according to claim 9, 10 or 11, wherein the pump comprises an electrically driven pump.

13. A system according to any preceding claim, wherein the system is controlled to modify the flow route of the engine coolant to enhance the HVAC effect of the HVAC heat exchanger.

14. A system according to claim 13, wherein the system includes a valve arrangement controlled to modify the engine coolant flow to enhance the HVAC effect of the HVAC heat exchanger.

15. A system according to claim 13 or claim 14, wherein the system includes a thermostat valve arrangement controlled to modify the engine coolant flow to enhance the HVAC effect of the HVAC heat exchanger.

16. A system according to any preceding claim, wherein the system is controlled to be operated such that in cold or cool ambient conditions, when the system is placed under a user demand situation for the interior of the vehicle to be heated, the engine

coolant flow to the HVAC heat exchanger is modified to enhance the HVAC effect of the HVAC heat exchanger.

17. A method of operating a HVAC system including a HVAC heat exchanger having an air-side and an engine coolant side, the HVAC heat exchanger being arranged to exchange heat between air to be directed into the interior of the vehicle and engine coolant; the method comprising modifying the engine coolant flow to enhance the HVAC effect of the HVAC heat exchanger.

18. An automotive HVAC system including:

a HVAC heat exchanger having an air-side and an engine coolant side, the HVAC heat exchanger being arranged to exchange heat between air to be directed into the interior of the vehicle and engine coolant;

a monitoring arrangement for monitoring the temperature of the engine coolant and/or the air delivered to the interior of the vehicle;

and one or both of ;

a pump to pump the engine coolant, the pump being controllable to increase the pumping rate of the engine coolant in predetermined demand conditions, preferably the pump being operated at its maximum pumping rate during an initial warm-up period of the engine;

a valve arrangement arranged to modify the route of the engine coolant in the engine coolant circuit in predetermined demand conditions.

Application No: GB 0311399.0
Claims searched: 1 - 18
Examiner: Stephen Hart
Date of search: 20 October 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X	1 - 10 & 12 - 18	US 3999598	(SUEDDEUTSCHE) whole document, noting a motor vehicle heating and air conditioning system having a primary circuit (I) and a secondary circuit (II) having a variable speed electric pump 4 driven independently of the engine depending on the temperature at one or more outlet sensors 8.
X	1 - 3, 6, 7 13 - 15 & 17	GB 2227829 A	(BUDAPESTI) fig 1, noting an appliance for heating motor vehicles having an electric pump 24 driven independently of the engine depending on the temperature at a heat sensor 28.
X	1 - 3, 6, 7 13 - 15 & 17	US 3779307	(WEISS et al.) whole document, noting a heating and cooling system for motor vehicles having an additional pump 12 driven independently of the engine.
X	1 - 3, 6, 7 & 17	US 4308994	(AUTOTHERM) fig 1, noting a vehicular heating system comprising a hot water circulation device 7 driven independently of the engine.
X	1 & 17 at least	DE 19506935 C1	(MERCEDES-BENZ) 04.04.96 (see figure 1 and also WPI Abstract Accession No. 1996-172586 [18]), noting a vehicle heating circuit having an electric pump 10 driven independently of the engine and is speed or cycle controlled.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art
Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[V]:

F4U, F4V

The Patent Office

INVESTOR IN PEOPLE

Application No:	GB 0311399.0	**Examiner:**	Stephen Hart
Claims searched:	1 - 18	**Date of search:**	20 October 2003

Worldwide search of patent documents classified in the following areas of the IPC[7]:

B60H, F01P

The following online and other databases have been used in the preparation of this search report:

Online: WPI, EPODOC, JAPIO, TXTE